National Park Service
Rock Creek Park
Curriculum Based Program

Powered on Water and Gravity, the Workings of a Mill

Students will marvel at how Peirce Mill was designed to clean, grind and sift grain into flour using only the power of water and gravity as they take an in-depth look into America's first fully automated factory.

Curriculum Based Topics:

Energy, simple machines, water resources, location and growth, technological changes

Background Information:

Milling was nothing new. People had been grinding grains over 75,000 years and the Greeks are thought to have been the first to create a commercial mill. However, in 1795, Oliver Evans revolutionized milling in America. In his book, The Young Millwright and Miller's Guide, Oliver Evans described the first fully automated mill. Not only did the water power the grinding process, but it also powered the cleaning and sifting processes as well. Two grain elevators, which were powered by the water, and chutes utilizing gravity, moved the grain from one machine to the next.

This leap in technology was extremely important at the time. Between 1780 and 1860, a period known as the American Industrial Revolution, the nation was expanding westward, able- bodied men were needed to blaze trails, set up posts and fight Native Americans. There simply were not enough people to do all the work. Therefore, many of the technological changes, like those inside Peirce Mill, made jobs simpler and reduced the number of people needed to complete them. It was a time of immense change in technology spurred mostly by the need to "do more with less people."

The effects of this technology were far reaching. It reduced the number of people needed to work the mill from 6 or more to 1 or 2. Flour and other grain products became cheaper to make and to buy. The technological aspects were also felt in other industries, including textiles, where automated mills soon followed. Today, many of our products are manufactured at automated factories.

Audience: Grades 5-6.

Length: 1 Hour.

Location: Peirce Barn (2401 Tilden Street, NW) or Peirce Mill

Students per group: maximum of 30

Chaperones per group: 3-5

Curriculum Based, Standards of Learning (Virginia Standards):

Force, Motion, and Energy
- 4.2 The student will investigate and understand that energy is needed to do work and that machines make work easier. Key concepts include * energy forms (electrical, mechanical, and chemical energy); * potential and kinetic energy; * simple and complex machines; and * efficiency, friction, and inertia.

Resources
- 4.8 The student will investigate and understand important Virginia natural resources. Key concepts include * watershed and water resources; * animals and plants, both domesticated and wild; * minerals, rocks, ores, and energy sources; and * forests, soil, and land.

Geography
- 4.1 *The student will explain the impact of geographic factors in the expansion and development of Virginia, with emphasis on; * the location and growth of cities in relation to the Atlantic Ocean, the Chesapeake Bay, major rivers, the fall line/fall zone, and the Shenandoah Valley.
- 4.5 The student will evaluate the social, political, and economic life in Virginia from the Reconstruction Period to the 20th century, with emphasis on * the economic and social transition from a rural, agricultural society to a more urban, industrialized society.

History

- 5.6 The student will describe growth and change in America from 1801 to 1861, with emphasis on * territorial exploration, expansion, and settlement, including the Louisiana Purchase, the Lewis and Clark expedition, the acquisition of Florida, Texas, Oregon, and California; * how the effects of geography, climate, canals and river systems, economic incentives, and frontier spirit influenced the distribution and movement of people, goods, and services.

- 5.9 The student will develop skills for historical analysis, including the ability to * identify, analyze, and interpret primary sources (artifacts, diaries, letters, photographs, art, documents, and newspapers) and contemporary media (television, movies, and computer information systems) to better understand events and life in United States history to 1877; * construct various time lines of American history from pre- Columbian times to 1877 highlighting landmark dates, technological changes, major political and military events, and major historical figures

Goals: The program will:
1. Explain what was happening in and around Peirce Mill in 1820.

2. Describe the process of milling.
3. Relate the benefits of using the power of water and gravity instead of people.

Safety and Resource Management Message:
1. Please do not harm, harass, or remove any native plants, animals, or historic artifacts from the park.

Books for the Classroom:

Life in America's First Cities. Isaacs, Sally Senzell. Heinemann. 2001.
Looks at the lives of the first Americans to set up cities in the United States. Discusses homes, shelter, food, clothes, schools, communications, and everyday activities.

Life on a Southern Plantation. Isaacs, Sally Senzell. Heinemann. 2001.
Looks at the lives of the first Americans to set up plantations in the United States. Discusses homes, shelter, food, clothes, schools, communications, and everyday activities.

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Pre-visit Activities:

A) Milling Minds (from MCPS Social Studies field trip to Peirce Mill):

1. Conduct a brainstorming session in which the class generates words or phrases they would associate with mills. Ask them to group the words according to commonalties and explain their reasons for such classification.

2. Ask students to determine the sequence of events needed to produce flour in the nineteenth century. The events below are in correct order. Present them on paper in scrambled order and have students (working in pairs or teams) cut them in strips and arrange them in the order they think is correct. Discuss the order with the entire class:

1. A farmer grows fields of wheat and corn.
2. The farmer harvests the wheat and corn.
3. The farmer transports the wheat and corn to the mill.
4. The miller buys the wheat and corn from the farmer.
5. The miller cleans the wheat and corn.
6. Then the miller grinds the wheat and corn.
7. As the wheat and corn is ground, it becomes flour.
8. The miller sells the flour to a local general store.
9. The local general store sells it to consumers.

3. Review with students the meaning of these economic terms:
- production - putting resources together to make goods or provide a service.
- natural resources - those things found in or on the earth.
- human resources - people doing mental or physical work.
- capital resources - resources made by people and used to produce other goods and services. (Money is not considered a capital resource.)

Using the sequence of events in flour production, have the class give examples of some of the human resources (farmer, miller, wagon driver, grocer), the natural resources (land, water, seeds, etc.), and the capital resources (wagon, mill and milling machinery, harvesting equipment, bins for flour in store, etc.). Record on a class chart titled "Resources Needed in Flour Production."
- If information is available, compare the nineteenth century milling approach with the modern process for producing flour. Compare the two, noting technological changes.

- Review with students to familiarize them with the specific vocabulary associated with a mill and the operation and design of the nineteenth century machinery.

- Have students predict the time of year a nineteenth century mill would have been the busiest. Have them explain their predictions.

B) Mapping the Mill (from MCPS Social Studies field trip to Peirce Mill):

Using a map of Rock Creek Park or D.C. locate Peirce Mill. Brainstorm with class why a mill would be built near a river or creek. Have the students locate Peirce Mill on a street map of Washington, D. C. Then, have them determine two routes the bus might take to get them there. Have the students estimate the distance to the mill and the length of time it will take to get there for each route.

C) The Peirce Mill

The Peirce family presence in Maryland can be traced back to Isaac Peirce, who left Pennsylvania in the 1780's. Isaac worked for Abner Cloud as a millwright, a person who builds and repairs mill equipment. In 1794, Isaac bought 150 acres of land including a mill, using Oliver Evan's patented design. In 1820, Isaac and his son, Abner, rebuilt the mill. When Isaac Peirce died in 1841, he left all his property to his son.

For ten years, Abner managed the mill. After his death, his nephew inherited the property.

Business was brisk at Peirce Mill, especially in the 1860's. As many as 12 wagonloads of wheat arrived for milling each day. Peirce Mill is located less than five miles from the White House. At one time, Rock Creek valley was being considered as a site for relocation of the presidential mansion. Instead, Congress took the advice of Major Nathaniel Michel who recommended that the valley be preserved as a public park. In 1890 Congress created Rock Creek Park.

The Federal Government condemned Peirce Mill in 1892 and milling stopped in 1897. The mill then served as a teahouse until the 1930's. The National Park Service assumed the care of Rock Creek Park in 1933. In 1934, the Secretary of the Interior suggested that Peirce Mill be restored. Two years later, it was in operation again. By 1958, the mill was in need of repair and was closed again. A second renovation was performed in 1967, and the mill operated again until the main shaft warped in 1993.

1) Create a time line to show the major events in the history of Peirce Mill. Be sure to give your time line an appropriate title.

2) Look at a map of Rock Creek Park. What are some of the features that would make this a desirable location for the White House?

D) Simple Machines

Peirce Mill is run by a series of **simple machines**. In the next few activities, you will learn about some of the simple machines used in the mill.

1) Place one hand under the edge of a table and gently lift upward. Try to lift the table off of the floor. (Warning: Do not strain if the table is heavy!) Describe what happened.

2) Place the back of a chair about 10-12 cm from the edge of the table. Place a broom handle over the back of the chair and under the edge of the table. Place your hand on the straw end of the broom and push down gently. Describe what happened.

3) Which would you rather use to lift the side of the table by yourself, your arm or the broom? Choose an answer below.

A) My arm because it is harder to use than the broom.

B) My arm because it is easier to use than the broom.

C) The broom because it is harder to use than my arm.

D) The broom because it is easier to use than my arm.

What do you think of when someone says the word "**machine**"? A compact disc player, a television, a bulldozer, or a crane? Maybe you think of a car, bus, or train. Is a pencil sharpener, a playground seesaw, or a flagpole a machine? **Simple machines** help us do work. Although they don't reduce the amount of work, simple machines make work easier. Machines work easier by changing the amount of force needed or by changing the direction of the force.

4) Scientists define a machine as any device that changes either the direction or the amount of force that you must apply to accomplish a task. Was the broom you just used a machine? Be sure to explain your thinking.

5) What would you call this machine?

Read the description below to find out about the type of machine you just used, it is called a lever. You will be reading for information. When you are reading to be informed you should:

- Read the material carefully.

- Pause during your reading to organize new information in your head and link it to what you already know.

A **lever** is one of the most common simple machines. It is a simple machine that can help lift a weight with less effort. All levers have a bar and a turning point, the fulcrum. The force applied to the lever is the **effort** put into moving the simple machine. The object that is actually being moved is called the **load**.

A screwdriver can be used as a lever to pry the top off the lid of a paint can. FIrst you would put the tip of the screwdriver underneath the lid of the can.

The bar of the screwdriver would be resting on the top of the can, which would act as the fulcrum. You would then push down on one end of the screwdriver (the effort) and the other end would move up, lifting the lid (the load) off of the can.

The lever changed the direction of the force and moved the lid up. The simple machine has made your work easier!

E) Levers

You will be constructing a lever system using a pencil and a ruler. **Read the question you will be investigating about the lever and the entire procedure below before you beign the experiement.**

Question: How does changing the distance between the fulcrum and the load on a lever affect the amount of force needed to lift the load?

Materials Needed:

- ruler, one marble

- two cups (plastic or paper), 25 pennies (or metal washers)

- masking tape, one pencil

Procedure:

1) Tape one cup to each end of the ruler.

2) Slide a pencil directly underneath the ruler at 9 cm to create a fulcrum.

3) Place a marble in the cup that is at the 30 cm end of the ruler.

4) Place pennies in the cup at the 0 cm end of the ruler one at a time until the cup with the marble lifts off of the table.

5) Empty the pennies from the cup and repeat the procedure to collect data for two more trials with the fulcrum at 9 cm.

6) Move the fulcrum to 11 cm on the ruler. Collect data for three trials.

7) Repeat the entire procedure with the fulcrum at 13 and 15 cm.

8) Find the mean (average) number for the data.

Questions:

- What is being used as the fulcrum?

- What is the load?

- What is the effort (force)?

1) Write a prediction for this investigation. Be sure to include a reason for your thinking.

2) Now complete the investigation with your group and record your data below. Round the mean to the nearest whole number. Follow the procedure from the previous page.

Force Needed to Lift a Load with the Fulcrum at Different Positions

Position of fulcrum- Trial One, Trial Two, Trial Three, Mean (Average)

9 cm

11 cm

13 cm

15 cm

3) Study the data you collected. If you moved the fulcrum to the 17 cm mark, do you think you would need more pennies or fewer pennies to lift the load then you did with the fulcrum at the 15 cm mark? Choose an answer from below.

A) More pennies because the fulcrum is closer to the load so it makes it easier to lift.

B) More pennies because the fulcrum is closer to the load so it makes it harder to lift.

C) Fewer pennies because the fulcrum is closer to the load so it makes it easier to lift.

D) Fewer pennies because the fulcrum is closer to the load so it makes it harder to lift.

4) Write a conclusion to the investigation. In your conclusion:

- answer the original question: How does changing the distance between the fulcrum and the load on a lever affect the amount of force needed to lift the load?

- support your answer with data collected in the investigation.

- state whether your prediction was supported or not by the data in the investigation.

5) If you had to move a tree stump, what would you do with your fulcrum (the rock) to make the job as easy as possible for yourself? Draw a picture and choose an answer from below.

A) Move the fulcrum (rock) farther away from the load (tree stump) because that will make it easier to lift.

B) Move the fulcrum (rock) closer to the load (tree stump) because that will make it easier to lift.

C) Keep the fulcrum (rock) where it is located now.

F) Pulleys

A **pulley** is a useful machine for lifting heavy objects. A pulley is a small wheel with a groove in the rim in which a rope or belt moves.

There are two types of pulleys, **fixed** and **moveable**. A fixed pulley stays in place. An object is fastened to one end of the rope and is lifted by pulling down on the other end of the rope. A flagpole uses a fixed pulley. You will work with a partner for this investigation to examine how a fixed pulley works.

Directions:

1) Cut a two meter piece of string, thread the string through (or over) the pulley, and tie the ends of the string together.

2) Make a paper flag.

3) Fold a tiny edge of the flag over the string and tape the back to hold the flag to the string.

4) Have your partner hold the pulley up in the air in one place. Adjust the string so the flag is hanging at the bottom of the loop.

5) Using a marker, make a mark at the top of the string where it rests on top of the pulley.

6) Pull down on the string opposite the flag until the flag has reached the top.

7) Observe the distance the string is pulled down and the distance the flag moves. Look at where the black mark on the string ends up.

Questions:

1) When you pulled down on the string, what direction did the flag move? Was it in the same or the opposite direction?

2) What did you notice about the distance the string is pulled down as compared to the distance the flag moved upward?

3) Write a description or draw a picture of a situation where a fixed pulley might be used to lift something heavy.

Placing the fixed pulley at the top of a flag pole makes the job a raising a flag easier because the pulley allows you to pull down on the rope and raise the flag. This is easier than trying to carry the flag up the pole. Pulling a rope down is more comfortable than lifting an object, but actually the pulley has only changed the direction of the effort. The rope goes down and the flag goes up. The distance traveled is the smae for both the flag and the rope being pulled. To raise a flag up two meters, you must pull the rope down two meters.

Another type of pulley is the **moveable pulley**. Moveable pulleys are attached to the load and move with the load.

Moveable pulleys allow you to use less force to raise an object than just lifting it by hand. They make work easier by decreasing the amount of force needed to move the object. This means more distance is involved. Two ropes now support the object's mass equally. When a force is applied to the rope, the rope moves twice the distance that the object moves but you only have to use half the effort.

A system that uses more than one pulley is called a **block and tackle**. The pulleys are the block and the rope is the tackle. A block and tackle uses one rope wound around two or more different pulleys. The upper set of pulleys is fixed to a support such as a beam and the lower set of pulleys is moveable, being attached to the load. A car mechanic can lift an engine with two fingers using a pulley system with several pulleys. The more pulleys used, the easier the job gets.

4) Write a description or draw a picture of a situation where a moveable pulley might be used to lift something heavy.

G. Gears

You have studied the **lever** and the **pulley**. There are other simple machines you might be familiar with, as well. The following activity will give you a short introduction to the **gear**, which is actually a wheel.

If you have ever used a hand-held can opener to open a can, you have used a gear system. Gears are another type of simple machine. Gears are found inside many clocks, toys, and as part of many different tools. A gear is a special type of wheel with teeth evenly spaced around the edge. When the teeth of two gears fit together and one gear turns, it will cause the other gear to turn. The second gear can turn a third gear, and so on. While the large gear turns one direction a few times, the small gear turns the opposite direction many times.

1) Nail three bottle caps into a piece of wood (close together) to see how gears work. Look at the model. Move the first bottle cap gear on the left and observe how all the other bottle cap gears move. Write your observations in the space below.

2) Based on what you observed with the bottle cap gears, draw arrows around the gears to show which way the gears will turn.

3) You have learned about milling and some of the simple machines that help mill grain into flour. You will continue your study at the mill in your classroom after your visit.

Pay close attention to the simple machines at the mill. Enjoy your visit to Peirce Mill.

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Post-visit Activities:

A) From MCPS Social Studies Field trip to Peirce Mill:

1. Using the information they collected, have students discuss and complete the class brainstorming session and words or phrases charts that they started prior to the field trip.

2. Ask students to verify, correct, and make additions to their sequence for production of flour in the nineteenth century. Then provide students with story boards to create a slide show on the sequence of events necessary to make flour. Have them make sketches and write a rough draft of the script. As a class, place the "slides" in order and evaluate and edit the script. Then have students record the script for each picture.

3. Ask several students to research the various kinds of water wheels. If possible, provide the materials and/or time for them to build a model and share their work with the class.

4. Have several students investigate the life of Anna Eugenia Emma Schneider (b. 1889) who was known as the country's first woman miller. Her Baltimore business produced "Eugenia Whole Wheat Flour" and supplied several hundred tins of biscuits for Admiral Byrd's 1939 expedition to the Antarctic. One source for information is Notable Maryland Women, edited by Winifred G. Helmes (Cambridge, MD: Tidewater Press, 1977).

B) Review

Think back over your Peirce Mill experience. You have learned a lot about the milling process and how an automated mill works. Review some of the important information you learned during your visit to the mill.

Gears

Levers

Pulleys

Gravity

Water power

C) Designing your Machine

Now it is time to design your Rube Goldberg type machine. Visit **www.rubegoldberg.com** to see examples of other Rube Goldberg machines.

When people hear Rube Goldberg's name, they think of doing something simple in a difficult way. Below are a few simple everyday tasks. Brainstorm with your class other simple things you do everyday that could be the subject of a cartoon. Add them to the list already started.

- Waking up in the morning, making a piece of toast

- Putting toothpaste on a toothbrush, pouring a cup of water

- Putting a stamp on a letter, opening a door

1) Choose one of the tasks from above, one of your classmates thought of, or an idea of your own as your subject. Create a Rube Goldberg-like cartoon to accomplish the simple everyday task you picked. Your cartoon, like Rube Goldberg's, will include a drawing as well as a description of how it works. Follow the steps below to complete your cartoon.

- Draw a picture that shows how the task is accomplished. Use at least two different simple machines.

- Place a letter next to each object in the drawn cartoon and write a description using the letters of how the objects work together.

- Give the cartoon a title.

- Use the checklist given to you by your teacher to guide your work. Your teacher will also use this checklist to evaluate your drawing.

2) Design your machine on a separate piece of paper. Make sure you label each part with a letter so you can write a description of your machine.

3) Write a description for each part of the machine you labeled with a letter. (Look at a Rube Goldberg cartoon from **www.rubegoldberg.com** as an example).

4) Identify the simple machines you included as part of your cartoon. Describe how you used each one.

5) What was the power source for your machine?

6) What other power sources could be used?

7) How did scientific information you learned about simple machines help you design your cartoon? Give a specific example.